

CLAIMS

- 1 1. An apparatus for improving Transmission Control Protocol (TCP) performance,
2 the apparatus comprising:
- 3 at least one processor;
- 4 a memory coupled to the at least one processor; and
- 5 an acknowledgment adjuster, the acknowledgment adjuster monitoring
6 network transmission traffic and adjusting use of delayed
7 acknowledgments (ACKs) based on the network transmission traffic.
- 1 2. The apparatus of claim 1 wherein the acknowledgment adjuster:
- 2 monitors whether an acknowledgment (ACK) was not sent during a
3 predetermined time period after a first packet was received; and
- 4 sends an ACK after each received packet if an ACK was not sent during a
5 predetermined time period after a first packet was received.
- 1 3. The apparatus of claim 1 wherein the acknowledgment adjuster monitoring
2 network transmission traffic and adjusting use of delayed ACKs further
3 comprises:
- 4 the acknowledgment adjuster monitoring packet receipt frequency and
5 adjusting use of delayed ACKs based on packet receipt frequency.

1 4. The apparatus of claim 1 wherein the acknowledgment adjuster:
2 determines a time period between when a last ACK for a previous packet
3 was sent and when a current packet is received; and
4 if the time period between when a last ACK for a previous packet was sent
5 and when a current packet is received is less than a predetermined time
6 period:
7 discontinues sending an ACK after each received packet; and
8 sends a delayed ACK after at least one received packet.

1 5. The apparatus of claim 4 wherein the at least one received packet is the current
2 packet.

1 6. The apparatus of claim 4 wherein the previous packet and the current packet are
2 full sized packets.

1 7. The apparatus of claim 1 wherein the acknowledgment adjuster:
2 determines a time period between when a last ACK was sent and when a
3 data packet is to be sent in return to a previous packet; and
4 if the time period between when a last ACK was sent and when a data
5 packet is to be sent in return to a previous packet is less than the
6 predetermined time period:
7 discontinues sending an ACK after each received packet; and
8 sends a delayed ACK after at least one received packet.

1 8. The apparatus of claim 1 wherein the acknowledgment adjuster:
2 upon receiving a current packet determines if the acknowledgment adjuster
3 is to send delayed ACKs after receiving packets, and if the
4 acknowledgment adjuster is to send delayed ACKs after receiving packets;
5 sends a delayed ACK after receiving at least one packet; or
6 if the acknowledgment adjuster is to not send delayed ACKs after
7 receiving packets;
8 sends an ACK after each received packet.

1 9. The apparatus of claim 2 wherein the acknowledgment adjuster:

2 determines if a first time period between when a last ACK was sent and
3 when a current packet is received is less than the predetermined time
4 period, and if a first time period between when a last ACK was sent and
5 when a current packet is received is less than the predetermined time
6 period:

7 discontinues sending an ACK after each received packet; and

8 sends a delayed ACK after at least one received packet; or

9 determines if a second time period between when a last ACK was sent and
10 when a data packet is to be sent in return to a current packet is less than
11 the predetermined time period, and if a second time period between when
12 a last ACK was sent and when a data packet is to be sent in return to a
13 current packet is less than the predetermined time period:

14 discontinues sending an ACK after each received packet; and

15 sends a delayed ACK after receiving at least one subsequent
16 packet.

1 10. The apparatus of claim 9 wherein the at least one subsequent packet is the current
2 packet.

1 11. An apparatus for improving Transmission Control Protocol (TCP) performance,
2 the apparatus comprising:
3 at least one processor;
4 a memory coupled to the at least one processor; and
5 an acknowledgment adjuster, the acknowledgment adjuster monitoring
6 time delays in TCP traffic, these delays occurring between
7 the last acknowledgment time of a first data packet and receipt of a
8 subsequent data packet, and
9 the last acknowledgment time of a first data packet and a response
10 data packet sent in reply to a first data packet, and
11 the receipt of a first data packet and the ACK of that first data
12 packet; and
13 the acknowledgment adjuster adjusting use of delayed ACKs based on
14 time delays which occur in the TCP traffic such that
15 if the use of delayed ACKs is disabled and the time delay between
16 the last acknowledgment time and receipt of a subsequent data
17 packet is less than a predetermined time period, use of delayed
18 ACKs is enabled; or
19 if the use of delayed ACKs is disabled and the time delay between
20 the last acknowledgment time and a reply to the first data packet
21 with a response data packet is less than a predetermined time
22 period, use of delayed ACKs is enabled; or

23 if the use of delayed ACKs is enabled and the delay in sending an
24 ACK in response to a first data packet exceeds a predetermined
25 time period, use of delayed ACKs is disabled.

1 12. The apparatus of claim 11 wherein the acknowledgment adjuster
2 stores the current time as the last acknowledgment time when an ACK is
3 sent in response to a data packet received.

1 13. The apparatus of claim 11 wherein the acknowledgment adjuster
2 stores the current time as the last acknowledgment time when an ACK is
3 combined and sent with a response data packet in reply to a first data
4 packet.

1 14. The apparatus of claim 11 wherein the predetermined time period is 200
2 milliseconds.

1 15. The apparatus of claim 11 where the acknowledgment adjuster adjusts use of
 2 delayed ACKs based on time delays which occur in the TCP traffic such that if the
 3 use of delayed ACKs is disabled and the time delay between the last
 4 acknowledgment time and receipt of a subsequent data packet is less than a
 5 predetermined time period further:

6 obtains the difference in time between the last acknowledgment time and
 7 the current time when receiving a data packet,
 8 compares that difference in time to a predetermined time period, and
 9 if the difference in time is less than the predetermined time period, uses
 10 delayed ACKs on subsequent data packets.

1 16. The apparatus of claim 11 wherein the acknowledgment adjuster adjusts use of
 2 delayed ACKs based on time delays which occur in the TCP traffic such that if the
 3 use of delayed ACKs is disabled and the time delay between the last
 4 acknowledgment time and a reply to the first data packet with a response data
 5 packet is less than a predetermined time period further:

6 obtains the difference in time between the last acknowledgment time and
 7 the current time when a response data packet is to be sent in reply to a
 8 previous data packet,
 9 compares that difference in time to a predetermined time period, and
 10 if the difference in time is less than the predetermined time period, enables
 11 use of delayed ACKs on subsequent data packets.

1 17. The apparatus of claim 11 wherein the acknowledgment adjuster adjusts use of
2 delayed ACKs based on time delays which occur in the TCP traffic such that if the
3 use of delayed ACKs is enabled and the delay in sending an ACK in response to a
4 first data packet exceeds a predetermined time period further:

5 starts a delay timer, set to expire after a predetermine amount of time,
6 when a first data packet is received and acknowledgment of that first data
7 packet is delayed, and

8 if that delay timer expires, sends an ACK for the first data packet
9 and disables use of delayed ACKs, or

10 if a subsequent data packet is received before the delay timer
11 expires, clears the delay timer and sends a delayed ACK for both
12 the first data packet and the subsequent data packet, or

13 if a response data packet is to be sent in reply to a first data packet
14 before the delay timer expires, clears the delay timer and combines
15 and sends a delayed ACK with the response data packet.

1 18. The apparatus of claim 17 where the acknowledgment adjuster sends a delayed
2 ACK for both the first data packet and the subsequent data packet further:

3 stores the current time as the last acknowledgment time.

1 19. The apparatus of claim 17 where the acknowledgment adjuster sends an ACK for
2 the first data packet further:

3 stores the current time as the last acknowledgment time.

1 20. The apparatus of claim 17 where the acknowledgment adjuster sends a delayed
2 ACK with the response data packet further:

3 stores the current time as the last acknowledgment time.

1 21. The apparatus of claim 17 where the predetermined time period is 200
2 milliseconds.

1 22. A method for improving Transmission Control Protocol (TCP) performance, the
2 method comprising the steps of:

3 monitoring traffic on a TCP connection; and

4 adjusting use of delayed acknowledgments (ACKs) based on the traffic.

1 23. The method of claim 22 wherein:

2 the step of monitoring traffic on a TCP connection comprises the step of
3 determining if an ACK was not sent during a predetermined time period
4 after a first packet was received; and

5 the step of adjusting use of delayed ACKs based on the traffic comprises
6 the step of sending an ACK after each received packet if an ACK was not
7 sent during a predetermined time period after a first packet was received.

1 24. The method of claim 22 wherein monitoring traffic on a TCP and adjusting use of
2 delayed ACKs based on the traffic connection further comprises:

3 monitoring packet receipt frequency on a TCP connection and adjusting
4 use of delayed ACKs based on packet receipt frequency.

1 25. The method of claim 23 wherein the step of the step of sending an ACK after each
2 received packet if an ACK was not sent during a predetermined time period after a
3 packet was received further comprises the steps of:

4 determining if a time period between when a last ACK was sent and when
5 a current packet is received is less than the predetermined time period; and

6 if a time period between when a last ACK was sent and when a current
7 packet is received is less than the predetermined time period:

8 discontinuing sending an ACK after each received packet; and

9 sending a delayed ACK after receiving at least one subsequent
10 packet.

1 26. The method of claim 25 wherein the at least one subsequent packet is the current
2 packet.

1 27. The method of claim 25 wherein the previous packet and the current packet are
2 full sized packets.

1 28. The method of claim 23 wherein the step of the step of sending an ACK after each
2 received packet if an ACK was not sent during a predetermined time period after a
3 packet was received further comprises the steps of:

4 determining a time period between when a last ACK was sent and when a
5 data packet is to be sent in return to a previous packet; and

6 if a time period between when a last ACK was sent and when a data
7 packet is to be sent in return to a previous packet is less than the
8 predetermined time period:

9 discontinuing sending an ACK after each received packet; and

10 sending a delayed ACK after at least one received packet.

1 29. The method of claim 22 wherein the step of adjusting use of delayed ACKs based
2 on the traffic further comprises:

3 upon receiving a current packet, determining if the use delayed ACKs is
4 enabled, and if the use of delayed ACKs is enabled;

5 sending a delayed ACK after receiving at least one packet; or

6 if the use of delayed ACKs is not enabled;

7 sending an ACK after each received packet.

1 30. The method of claim 23 wherein the step of the step of sending an ACK after each
2 received packet if an ACK was not sent during a predetermined time period after a
3 packet was received further comprises the steps of:

4 determining if a first time period between when a ACK was sent and when
5 a current packet is received is less than the predetermined time period, and
6 if a first time period between when a ACK was sent and when a current
7 packet is received is less than the predetermined time period:

8 discontinuing sending an ACK after each received packet; and

9 sending a delayed ACK after at least one received packet; or

10 determining if a second time period between when a last ACK was sent
11 and when a data packet is to be sent in return to a current packet is less
12 than the predetermined time period, and if a second time period between
13 when a last ACK was sent and when a data packet is to be sent in return to
14 a current packet is less than the predetermined time period:

15 discontinuing sending an ACK after each received packet; and

16 sending a delayed ACK after at least one received packet.

1 31. The method of claim 30 wherein the at least one subsequent packet is the current
2 packet.

1 32. A method for improving Transmission Control Protocol (TCP) performance, the
2 method comprising the steps of:

3 monitoring time delays in TCP traffic, these delays occurring between

4 the last acknowledgment time of a first data packet and receipt of a
5 subsequent data packet, and

6 the last acknowledgment time of a first data packet and a response
7 data packet sent in reply to a first data packet, and

8 the receipt of a first data packet and the acknowledgment of that
9 first data packet; and

10 adjusting use of delayed ACKs based on time delays which occur in the
11 TCP traffic such that

12 if the use of delayed ACKs is disabled and the time delay between
13 the last acknowledgment time and receipt of a subsequent data
14 packet is less than a predetermined time period, use of delayed
15 ACKs is enabled; or

16 if the use of delayed ACKs is disabled and the time delay between
17 the last acknowledgment time and a reply to the first data packet
18 with a response data packet is less than a predetermined time
19 period, use of delayed ACKs is enabled; or

20 if the use of delayed ACKs is enabled and the delay in sending an
21 ACK in response to a first data packet exceeds a predetermined
22 time period, use of delayed ACKs is disabled.

1 33. The method of claim 32 wherein the step of monitoring time delays in TCP traffic
2 further comprises

3 storing the current time as the last acknowledgment time when an ACK is
4 sent in response to a data packet received.

1 34. The method of claim 32 wherein the step of monitoring time delays in TCP traffic
2 further comprises

3 storing the current time as the last acknowledgment time when an ACK is
4 combined and sent with a response data packet in reply to a first data
5 packet.

1 35. The method of claim 32 wherein the predetermined time period is 200
2 milliseconds.

1 36. The method of claim 32 wherein the step of adjusting use of delayed ACKs based
2 on time delays which occur in the TCP traffic such that if the use of delayed
3 ACKs is disabled and the time delay between the last acknowledgment time and
4 receipt of a subsequent data packet is less than a predetermined time period
5 further comprises:

6 obtaining the difference in time between the last acknowledgment time
7 and the current time when receiving a data packet,

8 comparing that difference in time to a predetermined time period, and

9 if the difference in time is less than the predetermined time period, enable
10 the use of delayed ACKs on subsequent data packets.

1 37. The method of claim 32 wherein the step of adjusting use of delayed ACKs based
2 on time delays which occur in the TCP traffic such that if the use of delayed
3 ACKs is disabled and the time delay between the last acknowledgment time and a
4 reply to the first data packet with a response data packet is less than a
5 predetermined time period further comprises:

6 obtaining the difference in time between the last acknowledgment time
7 and the current time when a response data packet is to be sent in reply to a
8 previous data packet,

9 comparing that difference in time to a predetermined time period, and

10 if the difference in time is less than the predetermined time period, enable
11 the use of delayed ACKs on subsequent data packets.

1 38. The method of claim 32 wherein the step of adjusting use of delayed ACKs based
2 on time delays which occur in the TCP traffic such that if the use of delayed
3 ACKs is enabled and the delay in sending an ACK in response to a first data
4 packet exceeds a predetermined time period further comprises:

5 starting a delay timer, set to expire after a predetermine amount of time,
6 when a first data packet is received and acknowledgment of that first data
7 packet is delayed, and

8 if that delay timer expires, sending an ACK for the first data packet
9 and disabling use of delayed ACKs, or

10 if a subsequent data packet is received before the delay timer
11 expires, clearing the delay timer and sending a delayed ACK for
12 both the first data packet and the subsequent data packet, or

13 if a response data packet is to be sent in reply to a first data packet
14 before the delay timer expires, clearing the delay timer and
15 combining and sending a delayed ACK with the response data
16 packet.

1 39. The method of claim 38 wherein the step of sending a delayed ACK for both the
2 first data packet and the subsequent data packet further comprises:

3 storing the current time as the last acknowledgment time.

1 40. The method of claim 38 wherein the step of sending an ACK for the first data
2 packet further comprises:

3 storing the current time as the last acknowledgment time.

1 41. The method of claim 38 wherein the step of combining and sending a delayed
2 ACK with the response data packet further comprises:

3 storing the current time as the last acknowledgment time.

1 42. The method of claim 38 wherein the predetermined time period is 200
2 milliseconds.

1 43. A program product, tangibly embodying a program of machine-readable
2 instructions executable by a computer system, the program product comprising:
3 an acknowledgment adjuster program, the acknowledgment adjuster
4 program monitoring traffic on a TCP connection and adjusting the use of
5 delayed ACKs based on the traffic; and
6 signal bearing media bearing the acknowledgment adjuster program.

1 44. The program product of claim 43 wherein the signal bearing media comprises
2 transmission media.

1 45. The program product of claim 43 wherein the signal bearing media comprises
2 recordable media.

1 46. The program product of claim 43 wherein the acknowledgment adjuster program
2 monitoring traffic on a TCP connection and adjusting the use of delayed ACKs
3 based on the traffic further comprises:
4 the acknowledgment adjuster program monitoring packet receipt
5 frequency on a TCP connection and adjusting the use of delayed ACKs
6 based on the packet receipt frequency.

1 47. The program product of claim 43 wherein the acknowledgment adjuster program:

2 monitors whether an ACK was not sent during a predetermined time
3 period after a first packet was received; and

4 sends an ACK after each received packet if an ACK was not sent during a
5 predetermined time period after a first packet was received.

1 48. The program product of claim 43 wherein the acknowledgment adjuster program:

2 determines a time period between when a last ACK for a previous packet
3 was sent and when a current packet is received; and

4 if the time period between when a last ACK for a previous packet was sent
5 and when a current packet is received is less than a predetermined time
6 period:

7 discontinues sending an ACK after each received packet; and

8 sends a delayed ACK after at least one received packet.

1 49. The program product of claim 48 wherein the at least one received packet is the
2 current packet.

1 50. The program product of claim 48 wherein the previous packet and the current
2 packet are full sized packets.

1 51. The program product of claim 43 wherein the acknowledgment adjuster program:

2 determines a time period between when a last ACK was sent and when a
3 data packet is to be sent in return to a previous packet; and

4 if the time period between when a last ACK was sent and when a data
5 packet is to be sent in return to a previous packet is less than the
6 predetermined time period:

7 discontinues sending an ACK after each received packet; and

8 sends a delayed ACK after at least one received packet.

1 52. The program product of claim 43 wherein the acknowledgment adjuster program:

2 upon receiving a current packet determines if the acknowledgment adjuster
3 program is to send delayed ACKs after receiving packets, and if the
4 acknowledgment adjuster program is to send delayed ACKs after receiving
5 packets;

6 sends a delayed ACK after receiving at least one packet; or

7 if the acknowledgment adjuster program is to not send delayed ACKs after
8 receiving packets;

9 sends an ACK after each received packet.

1 53. The program product of claim 47 wherein the acknowledgment adjuster program:

2 determines if a first time period between when a last ACK was sent and
3 when a current packet is received is less than the predetermined time
4 period, and if a first time period between when a last ACK was sent and
5 when a current packet is received is less than the predetermined time
6 period:

7 discontinues sending an ACK after each received packet; and

8 sends a delayed ACK after at least one received packet; or

9 determines if a second time period between when a last ACK was sent and
10 when a data packet is to be sent in return to a current packet is less than
11 the predetermined time period, and if a second time period between when
12 a last ACK was sent and when a data packet is to be sent in return to a
13 current packet is less than the predetermined time period:

14 discontinues sending an ACK after each received packet; and

15 sends a delayed ACK after receiving at least one subsequent
16 packet.

1 54. The program product of claim 53 wherein the at least one subsequent packet is
2 the current packet.

1 55. A program product, tangibly embodying a program of machine-readable
2 instructions executable by a computer system, the program product comprising:

3 an acknowledgment adjuster program, the acknowledgment adjuster
4 program monitoring time delays in TCP traffic, these delays occurring
5 between

6 the last acknowledgment time of a first data packet and receipt of a
7 subsequent data packet, and

8 the last acknowledgment time of a first data packet and a response
9 data packet sent in reply to a first data packet, and

10 the receipt of a first data packet and the ACK of that first data
11 packet; and

12 the acknowledgment adjuster program adjusting use of delayed ACKs
13 based on time delays which occur in the TCP traffic such that

14 if the use of delayed ACKs is disabled and the time delay between
15 the last acknowledgment time and receipt of a subsequent data
16 packet is less than a predetermined time period, use of delayed
17 ACKs is enabled; or

18 if the use of delayed ACKs is disabled and the time delay between
19 the last acknowledgment time and a reply to the first data packet
20 with a response data packet is less than a predetermined time
21 period, use of delayed ACKs is enabled; or

22 if the use of delayed ACKs is enabled and the delay in sending an
23 ACK in response to a first data packet exceeds a predetermined
24 time period, use of delayed ACKs is disabled.

1 56. The program product of claim 55 wherein the signal bearing media comprises
2 transmission media.

1 57. The program product of claim 55 wherein the signal bearing media comprises
2 recordable media.

1 58. The program product of claim 55 wherein the acknowledgment adjuster program
2 stores the current time as the last acknowledgment time when an ACK is
3 sent in response to a data packet received.

1 59. The program product of claim 55 wherein the acknowledgment adjuster program
2 stores the current time as the last acknowledgment time when an ACK is
3 combined and sent with a response data packet in reply to a first data
4 packet.

1 60. The program product of claim 55 wherein the predetermined time period is 200
2 milliseconds.

1 61. The program product of claim 55 where the acknowledgment adjuster program
2 adjusts use of delayed ACKs based on time delays which occur in the TCP traffic
3 such that if the use of delayed ACKs is disabled and the time delay between the
4 last acknowledgment time and receipt of a subsequent data packet is less than a
5 predetermined time period further:

6 obtains the difference in time between the last acknowledgment time and
7 the current time when receiving a data packet,

8 compares that difference in time to a predetermined time period, and

9 if the difference in time is less than the predetermined time period, uses
10 delayed ACKs on subsequent data packets.

11 62. The program product of claim 55 wherein the acknowledgment adjuster program
12 adjusts use of delayed ACKs based on time delays which occur in the TCP traffic
13 such that if the use of delayed ACKs is disabled and the time delay between the
14 last acknowledgment time and a reply to the first data packet with a response data
15 packet is less than a predetermined time period further:

16 obtains the difference in time between the last acknowledgment time and
17 the current time when a response data packet is to be sent in reply to a
18 previous data packet,

19 compares that difference in time to a predetermined time period, and

20 if the difference in time is less than the predetermined time period, enables
21 use of delayed ACKs on subsequent data packets.

1 63. The program product of claim 55 wherein the acknowledgment adjuster program
2 adjusts use of delayed ACKs based on time delays which occur in the TCP traffic
3 such that if the use of delayed ACKs is enabled and the delay in sending an ACK
4 in response to a first data packet exceeds a predetermined time period further:

5 starts a delay timer, set to expire after a predetermine amount of time,
6 when a first data packet is received and acknowledgment of that first data
7 packet is delayed, and

8 if that delay timer expires, sends an ACK for the first data packet
9 and disables use of delayed ACKs, or

10 if a subsequent data packet is received before the delay timer
11 expires, clears the delay timer and sends a delayed ACK for both
12 the first data packet and the subsequent data packet, or

13 if a response data packet is to be sent in reply to a first data packet
14 before the delay timer expires, clears the delay timer and combines
15 and sends a delayed ACK with the response data packet.

1 64. The program product of claim 63 where the acknowledgment adjuster program
2 sends a delayed ACK for both the first data packet and the subsequent data packet
3 further:

4 stores the current time as the last acknowledgment time.

1 65. The program product of claim 63 where the acknowledgment adjuster program
2 sends an ACK for the first data packet further:

3 stores the current time as the last acknowledgment time.

1 66. The program product of claim 63 where the acknowledgment adjuster program
2 sends a delayed ACK with the response data packet further:

3 stores the current time as the last acknowledgment time.

1 67. The program product of claim 63 where the predetermined time period is 200
2 milliseconds.
